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GLOBAL ENERGY SYSTEM

A Strategic Reference Framework for Economics, Security, Geopolitics, Technology and Climate

Zohayr ERRACHDY
Researcher in Energy Issues

ENGLISH EDITION REVIEW

Reviewed by:
Dr. Mohamed Ben Daoud
Professor of Higher Education
and
Glen Fallon
Over 40 years of experience in the energy sector
Former CEO, Siemens Energy Morocco

Edition: As-Siraj Observatory for Energy Perspectives

Knowledge • Analysis • Exploration

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A reader’s guide to the global energy system

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Editorial note

This English edition presents a concise strategic framework for reading the global energy system through five connected dimensions: economics, security, geopolitics, technology and climate. The chapter-divider pages are designed as visual waypoints so that each analytical axis begins with a distinct editorial identity.

Methodological Preface

Conceptual Framework for Reading

This analytical approach to the global energy system is based on a methodology founded on three essential pillars, inspired by the approach adopted by energy researcher Zohayr ERRACHDY. These pillars provide the reader (policymaker) with solid critical tools before addressing the five axes:

1. Departure from Traditional Intellectual References: The necessity to move beyond narrow ideological bias, whether in favour of absolute privatisation (capitalist) or generalised nationalisation (communist), and to seek a "third way" or practical paths emerging from the nature of each energy system and the specificities of each country, away from pre-established patterns.

2. Realism: The imperative to take into account the real constraints of the political, economic and social context when evaluating any energy policy or strategy. The analysis must not be theoretical and ideal but grounded in field data and its limited capacities.

3. Critical Objectivity: The adoption of a critical and objective perspective, avoiding both exaggeration in justification (rosy vision) and pessimism (bleak vision), while proceeding with a continuous revision of postulates and evidence that might hinder a fair understanding of global transformations.

Objective of this Preface: To remind the policymaker that reading the energy dossier, despite its technical nature, remains a political and intellectual practice requiring methodological awareness that guards against bias and subjects data to critical scrutiny before any decision-making.

CHAPTER 01

Energy and Economy

Markets, growth, competitiveness and the structure of the global economy

GLOBAL ENERGY SYSTEM

AS-SIRAJ OBSERVATORY FOR ENERGY PERSPECTIVES

Energy is one of the foundations of the modern economy. Industrial production, transportation, agriculture, services, buildings, telecommunications and other economic activities require available, reliable and affordable energy. Energy is therefore not merely a commodity or an economic sector in its own right; it is a fundamental input into the functioning of the global economy.

Energy and Economic Growth

The development of modern economies has been linked to their ability to provide increasing amounts of energy. Industrial expansion, increased production, urbanisation, the development of transport and services have all driven energy demand higher. However, the relationship is not straightforward: an increase in energy consumption does not automatically mean equivalent economic growth. Countries now strive to obtain greater economic value while using less energy, through technological improvement and energy efficiency.

Energy and Global Markets

Not all countries produce the energy they need, and energy sources are not distributed uniformly across the world. International energy markets and flows have therefore developed, encompassing oil, gas, coal and electricity, as well as associated equipment and technologies. This means that energy security and the global economy also depend on countries' ability to secure their supplies and access international markets.

Key Players in the Energy Market

Global energy markets are driven not only by producers and consumers; they also involve states, organisations and international institutions with varied roles. The Organization of the Petroleum Exporting Countries (OPEC) is one of the most prominent players in the global oil market. It groups major oil-producing and exporting countries and aims to coordinate members' petroleum policies and contribute to market stability. Alongside OPEC, a cooperation formula between the Organisation and some non-member producers, known as OPEC+, has emerged to strengthen cooperation among producers for market stability.

In contrast, the International Energy Agency (IEA) represents over 80% of global energy consumers. This agency, created in 1974 to defend the interests of consuming countries against supply shocks, has expanded its scope to clean energy, while maintaining the protection of its members' supply security at the core of its mandate.

Here, the policymaker must understand that the global energy market is not governed by prices alone. Producing countries, consuming countries, international organisations, companies, infrastructure and geopolitical events all interact within it. Thus, understanding energy on a global scale requires knowing: who produces? who consumes? who exports? who imports? and who has the capacity to influence the market or cope with supply disruptions?

Energy Prices and the Economy

Fluctuations in energy prices can transmit to the economy in multiple ways. A rise in oil or gas prices, for example, can lead to increased transportation and production costs. This affects goods and services prices, inflation, competitiveness, trade balances and investment. For energy-exporting countries, a price increase can boost their revenues, while importing countries may bear additional burdens. The price of energy is therefore not just a market figure but an economic variable with wide-ranging implications.

Energy and Competitiveness

It is not enough for energy to be available; its cost and supply reliability have become elements of economic competitiveness. This is why countries compete not only for energy sources but also for access to secure and competitive energy, as well as for the development of infrastructure and technologies enabling them to produce and use it efficiently.

Energy Investment and Economic Structure

Energy projects are often characterised by the scale of investments and the length of planning, implementation and operational periods. Power plants, transmission networks, pipelines, energy ports, storage facilities, renewable energy projects and other infrastructure can influence the structure of the economy for years, even decades. Energy decisions therefore do not always have a short-term impact; they can determine part of the future economic structure.

The Energy Transition is Also an Economic Transition

The world is undergoing a transformation in how energy is produced and consumed, driven by economic, environmental, technological and geopolitical factors. This transition involves the expansion of renewables, electrification, energy storage, energy efficiency, electric vehicles, hydrogen and low-carbon technologies. This transition is not just about changing energy sources; it also creates new markets, investments, industries and value chains. Energy competition now includes technological, industrial, financial, skills and supply chain competition.

Energy and the Global Economic System

Energy cannot be considered in isolation from the global economy. Events occurring in the energy market can affect trade, investment and prices, just as countries' economic, industrial and technological decisions can modify energy demand and its sources. Understanding energy therefore requires considering it as part of an interconnected global economic system.

Summary of Chapter One:

Energy is not just a resource consumed by the economy but an element that influences growth, prices, competitiveness, trade, investment and economic structure. With the energy transition, economic competition is also linked to the capacity to develop technology, infrastructure, industry, skills and new value chains.

CHAPTER 02

Energy and Security

Supply continuity, resilience, infrastructure and crisis response

GLOBAL ENERGY SYSTEM

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Energy is no longer just an economic issue but also a security and strategic issue. The continuity of the economy, society, and the state's functioning depends on countries' ability to secure their energy supplies, cope with disruptions and maintain the operation of their energy systems under various circumstances. Energy security has thus become a fundamental element of states' economic and national security.

What is Energy Security?

Energy security can be defined as a state's ability to guarantee access to the energy it needs, reliably, continuously and at an affordable cost, while being able to withstand shocks and disruptions. This does not necessarily mean the state must produce all its energy needs locally. However, possessing local resources and production capacities strengthens its energy security and reduces its exposure to external risks. Similarly, countries partially dependent on imports can mitigate the risks of this dependence by diversifying energy sources, suppliers and routes, ensuring storage and reserves, and developing the necessary infrastructure and capacities to cope with crises.

Security of Supply

The primary question in energy security is: will energy be available when we need it? The presence of energy in markets does not guarantee its delivery to consumers. Wars, outages, political crises, disasters and transport disruptions can interrupt supplies. Energy security therefore concerns not only the quantity of available resources but also the system's capacity to access, transport, store, transform and distribute them.

Diversification of Energy Sources

Heavy dependence on a single source can increase a country's vulnerability. States therefore seek to diversify their energy mix among different sources such as oil, gas, coal, nuclear, hydroelectric, solar, wind, etc. The goal is not necessarily to abandon a particular source but to reduce the risks associated with excessive dependence on a single one.

Diversification of Suppliers

Even when a country depends on a specific energy source, diversifying the countries it sources from can reduce risks. Dependence on a single supplier exposes the state more to any political, economic or technical disruption affecting that supplier. Diversification of suppliers is therefore an element of building a more resilient energy system.

Diversification of Supply Routes

It is not enough to diversify countries and sources if all supplies transit through a single route. Energy can arrive via pipelines, maritime transport, ports and LNG terminals, electricity interconnections and other means depending on the energy type. The multiplicity of supply routes thus constitutes an additional asset for energy security.

Storage and Reserves

Storage helps cope with temporary supply disruptions. Its importance and nature vary depending on the energy type. There are petroleum and derivative reserves, as well as various forms of gas, electricity, thermal energy storage, etc. The fundamental idea is that a state with a margin of manoeuvre in the form of reserves is better equipped to face a temporary supply disruption.

Infrastructure and Networks

Energy security is not just about possessing resources. A power plant needs a transmission network; gas needs reception, transport and storage infrastructure; fuels need ports, storage facilities and distribution networks. Weak or failing infrastructure can lead to an energy crisis even when resources are available. In the electricity system particularly, networks, flexibility and reserves become essential elements for supply continuity.

Energy and Crisis Response Capacity

Energy systems can suffer various shocks: wars and conflicts, geopolitical crises, sanctions, trade and transport disruptions, natural disasters, technical failures, price fluctuations and supply chain disruptions. Energy security is therefore measured not only by the system's ability to operate under normal conditions but also by its capacity to persist, adapt and recover during shocks.

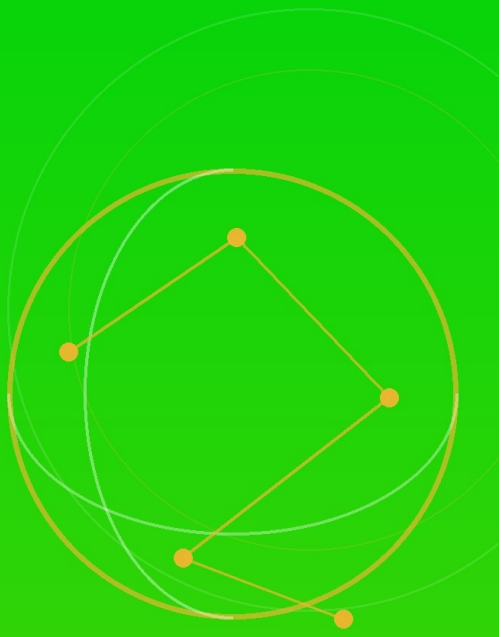
Energy Security No Longer Means Just Oil and Gas

The concept of energy security has evolved with the global energy system. With the expansion of electricity and renewables, system security is now linked to network integrity, flexibility, storage and the ability to balance supply and demand. Technology, supply chains for equipment, and metals needed for certain new energy technologies are also part of the energy security debate. The concept of energy security has thus moved from the question "Do we have enough fuel?" to a broader one: "Can we guarantee the continuous operation of our energy system under various conditions?"

Summary of Chapter Two:

Energy security means a state's ability to guarantee supplies, the continuous operation of its energy system and the management of shocks. Possessing local resources and production capacities strengthens this capability, as does the diversification of sources, suppliers and supply routes, the establishment of storage and reserves, the development of infrastructure and networks, and the reinforcement of flexibility and crisis response capacity. Energy security therefore does not rely on a single element but on an integrated system combining production capacity, diversity of sources and routes, infrastructure robustness, reserves, flexibility and crisis response capability.

CHAPTER 03



Energy and Geopolitics

Resources, strategic corridors, interdependence and power relations

GLOBAL ENERGY SYSTEM

AS-SIRAJ OBSERVATORY FOR ENERGY PERSPECTIVES

Energy is governed not only by economic and market logic but is also influenced by power relations, interests, geographic location and relations between states. This is primarily because energy resources are not distributed equitably among the world's countries, while consumption is distributed differently. This disparity creates interdependence between countries and regions, making energy an element of international relations.

Resource Distribution and Power Relations

Significant quantities of oil, gas and coal are concentrated in certain regions of the world, while major consumption centres are located elsewhere. This disparity gives some countries strategic importance as energy producers or exporters, while making others more dependent on external markets for their needs. A country's position in the global energy system can therefore be a source of power or a factor of weakness.

Producer Countries and Consumer Countries

The disparity between production and consumption zones creates complex relationships between states. Consumer countries need stable supplies, while exporting countries need markets and revenues. This interdependence can be a foundation for cooperation, partnerships and investments, but it can also become a source of tension when political or economic interests diverge.

Strategic Corridors and Infrastructure

It is not enough for energy to be present somewhere; it must reach markets. Certain geographic locations thus acquire importance beyond their size, such as straits and maritime passages, ports and shipping routes, oil and gas pipelines, LNG receiving and exporting terminals, and electricity interconnections. Any disruption on a major route can affect energy flows, prices and markets, with repercussions that may extend well beyond the affected area's countries.

Energy and Instruments of Power

Countries possessing significant energy resources or substantial production and export capacities can exert economic and political influence. Energy relations can be used to strengthen cooperation and partnerships but also as a tool of pressure or negotiation during certain crises. However, a state's energy power is measured not only by the volume of its resources but also by its production and export capacity, the infrastructure it possesses, the markets it accesses and its ability to influence supplies.

Interdependence and Points of Vulnerability

Interdependence is not necessarily negative, but it becomes a risk when dependence is excessive or difficult to compensate. Heavy dependence on a single source, a single supplier or a single route can make a state more vulnerable to political, economic or technical disruptions. The geopolitics of energy is therefore closely linked to the concept of diversifying sources, suppliers and supply routes.

Wars, Crises and Reshaping of Energy Markets

Wars, conflicts, sanctions and political crises can alter energy flows and global markets. Crises can push countries to seek new suppliers, develop alternative routes, increase storage or accelerate investments in other sources. A single geopolitical event can have repercussions on prices, trade, investment and energy security in regions far from its occurrence.

The Energy Transition Reshapes the Geopolitical Map

The energy transition does not mean the disappearance of energy geopolitics but its transformation. With the expansion of solar, wind, electric vehicles, batteries, networks and hydrogen, the importance of other elements grows: strategic metals, technology, industrial capacities and supply chains. Thus, some levers of power shift from simply possessing fossil resources to possessing the technology, industrial capacity, raw materials, infrastructure and knowledge necessary for the production and use of new energies.

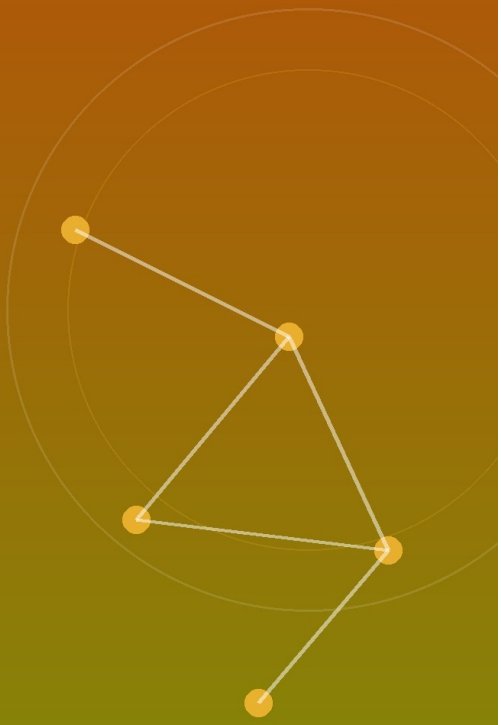
Energy and Foreign Policy

Energy relations have become a component of many countries' foreign policy. Pipeline projects, electricity interconnections, energy ports, supply contracts and joint investments can strengthen relations between states and create long-term mutual interests. Conversely, these same relations can become subjects of negotiation or competition when interests or geopolitical conditions change.

Summary of Chapter Three:

Energy is not just a commodity bought and sold on markets; it is also an element of power and international relations. Its geopolitical importance is determined by the distribution of resources, production and consumption locations, transport routes, infrastructure, industrial and technological capacities, and relations between states. With the energy transition, the geopolitics of energy does not disappear, but its map evolves, bringing new resources, technologies and poles of power.

CHAPTER 04



Energy and Technology

Innovation, systems, value chains and the transformation of energy

GLOBAL ENERGY SYSTEM

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The global energy system is transforming not only through the change in energy sources but also through the evolution of technology enabling the extraction, conversion, transport, storage and use of energy with greater efficiency. Technological progress has historically been one of the key factors expanding human capacity to use energy while altering economic and energy power balances among countries.

Technology and the Development of Energy Sources

Technological progress has enabled the exploitation of previously difficult or costly resources and increased the efficiency of energy conversion and use. This applies to oil, gas and coal, as well as solar, wind, hydro, nuclear and other energy sources. One cannot therefore understand the evolution of the energy system solely by the volume of natural resources; the ability to exploit a resource economically is also linked to the available technological level.

Electricity and Technology

Electricity has become a pivot of increasing importance in the global energy system, linked to the expansion of industry, services, digitalisation, electric transport, heating and cooling, data centres, etc. With the growing importance of electricity, the importance of technologies related to its production, transport, distribution, storage and grid management also increases.

Renewable Energies and Technological Progress

The deployment of solar, wind and other renewable energies depends heavily on technological progress. Improvements in the efficiency of solar panels, wind turbines, control systems and other technologies have contributed to better performance, reduced costs and expanded their scope of use. However, this technical progress does not eliminate the challenges related to the intermittency of some renewable sources. This in turn increases the importance of storage, networks, flexibility and demand management.

Storage and Networks

The higher the share of electricity in the energy system, the more crucial the ability to balance production and consumption becomes. The development of batteries and various storage systems, as well as modern networks, control and forecasting systems, has become a fundamental element of technological progress in the energy sector.

Nuclear Technology

Technological progress is not limited to renewables. The nuclear sector is also evolving in reactor design, safety systems, small modular and advanced reactors. The future of energy is not tied to a single technology but to a set of technological pathways that can compete with or complement each other.

Digitalisation and Artificial Intelligence

Digitalisation and artificial intelligence are gradually entering multiple areas of energy: demand and production forecasting, network management, predictive maintenance, optimisation of power plant operations, consumption management, data analysis and operational efficiency improvement. Data and the capacity to analyse them are becoming an increasing part of the energy system's technological infrastructure.

Technology and Energy Security

Energy security is now linked to technology itself. Countries need access to the equipment, software, skills, metals and materials required to build and operate modern energy systems. With the expansion of renewables, batteries, networks, etc., technological and industrial supply chains are part of global energy competition. Possessing natural resources is therefore no longer enough; the capacity to produce or access technology can become a factor of energy power.

Technological Uncertainty

Energy is characterised by decisions and investments often spanning years or decades, while technology can evolve at a pace difficult to predict. The cost of a given technology may decrease, its efficiency increase, an alternative technology emerge, or its competitiveness change in a period shorter than the project's lifespan. Technological forecasts should therefore not be treated as fixed truths but as hypotheses likely to evolve.

This does not mean postponing decisions until uncertainty disappears (which is impossible). Rather, long-term decisions must account for different scenarios, flexibility, adaptability and risks of technological obsolescence. In energy, today's decision may be based on today's technology, but the project will operate in a potentially different technological world tomorrow.

Technology and Competitiveness

It is not enough to know that a technology is technically possible. One must also consider its cost, efficiency, reliability, scalability, development time, required infrastructure, necessary skills and its ability to compete with alternatives. Technical feasibility therefore does not necessarily imply economic or strategic feasibility.

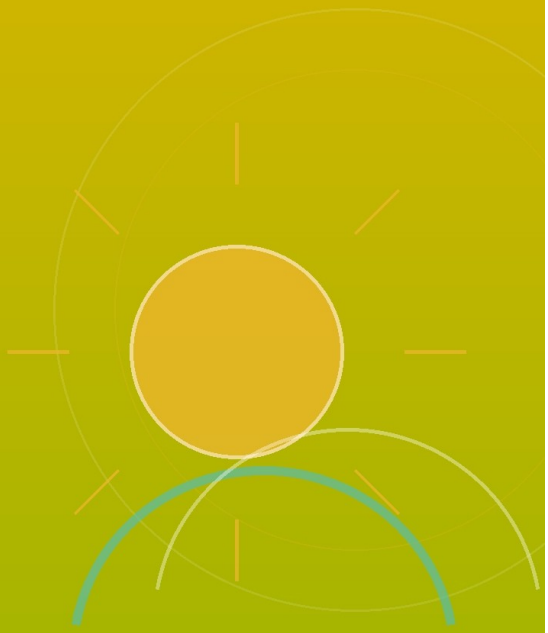
Technology and Power Relations

Technology has become an element of power in the global energy system. Countries possessing knowledge, industrial capacities, skills, R&D and value chains can gain a stronger position in new markets. Energy competition no longer focuses only on who owns the oil, gas, sun or wind, but also on who has the capacity to transform resources into economic value through technology.

Summary of Chapter Four:

Technology is not just a tool for improving energy production but a fundamental driver of the transformation of the global energy system. It is both a source of opportunities and uncertainties: technological progress can reduce costs and open new markets, but it can also make certain options less competitive in the future. Energy decisions must therefore combine technological knowledge, economic evaluation, flexibility and foresight, conscious that the technology underlying a decision today may not be the most competitive tomorrow.

CHAPTER 05



Energy and Climate

Transition, emissions, adaptation and the future of energy systems

GLOBAL ENERGY SYSTEM

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The relationship between energy and climate has become one of the most important issues reshaping the global energy system. This is fundamentally because a large part of the energy consumed worldwide still relies on fossil sources, and energy production and consumption are linked to a significant share of greenhouse gas emissions. However, the relationship between energy and climate is not just an environmental issue; it has also become an economic, technological, commercial and geopolitical one.

Energy and Climate Change

The increase in global concentrations of greenhouse gases has placed emissions reduction at the heart of international climate policies. Energy being one of the main sources of emissions, the transformation of energy production and consumption has become an essential element of international efforts to combat climate change. The climate issue is therefore increasingly linked to renewable energies, energy efficiency, electricity, clean transport, storage, nuclear, hydrogen and low-carbon technologies.

The Energy Transition is Not Simply Replacing One Source with Another

The energy transition does not simply mean replacing oil, coal and gas with solar and wind. It also includes reducing energy consumption through efficiency, electrifying various sectors, developing grids and storage, improving system efficiency, as well as developing low-carbon sources and new technologies. Moreover, the speed of this transition varies from country to country depending on its resources, economic capacity, infrastructure and technological development level.

Renewables and Low-Carbon Energy

It is important to distinguish between some concepts sometimes confused in public debate. Renewable energy is linked to a source that naturally renews itself, like the sun, wind and water. Low-carbon energy is broader and can include sources not dependent on fossil fuels and producing relatively low emissions over their entire life cycle, including nuclear in many classifications. Thus, not all low-carbon energy is renewable, and not all debates on the energy transition are limited to renewables.

Climate and Economy

The energy transition requires massive investments in production, networks, storage, transport, industry and technology. This poses a political and economic challenge: how to reduce emissions without weakening competitiveness and the capacity to provide energy at acceptable prices? On the other hand, the energy transition can create new economic opportunities through the emergence of industries and markets related to renewables, batteries, electric vehicles, hydrogen and low-carbon technologies. The climate transition is therefore not just a cost to bear but can also be a field of competition, investment, manufacturing and value creation.

Carbon Pricing and Carbon Tax

Some countries and regions use carbon pricing to integrate the cost of emissions into economic decision-making. This can take various forms, including a carbon tax, an emissions trading system, or other mechanisms that set a price or cost on emissions. The fundamental idea is that economic activity generating carbon emissions should bear part of their cost. As a result, emissions become a factor entering investment, production, and consumption decisions.

However, carbon pricing can also raise questions related to industrial competitiveness, prices, social justice and trade relations between states.

Carbon and International Trade

Climate policy is no longer confined within state borders. Some economies are beginning to link international trade to the emissions level associated with the production of goods. A notable example is the Carbon Border Adjustment Mechanism (CBAM) adopted by the European Union, which aims to address carbon emissions related to certain products imported into the European market. Climate policies can therefore become a factor affecting trade, competitiveness and market access. For export-dependent countries, reducing the carbon intensity of production becomes not just an environmental issue but also an economic and commercial one.

Developing Countries and Transition Financing

Not all countries have the same economic and technological capacities to undertake the energy transition. Developing countries often face simultaneous challenges: development needs, growing energy demand, limited financial resources, infrastructure needs, limited access to certain technologies, and the need to adapt to climate change impacts. International climate negotiations are therefore linked to questions of financing, technology transfer and support for developing countries.

Between Commitments and Implementation

It is important for the policymaker to consider climate finance realistically. International negotiations have seen multiple commitments to provide support to developing countries to help them reduce emissions and adapt to climate change. However, the gap between countries' commitments and the resources actually provided, as well as the nature and conditions of financing, have remained subject to controversy and constant criticism. Part of the debate concerns not just the volume of financing but also questions such as: is the financing new and additional? Is it grants or loans? What are their terms? Who receives them? Do they arrive in a timely manner and in sufficient quantity? The policymaker should therefore not treat international financing promises as guaranteed and automatically available resources.

Climate Justice

This gap raises a broader question about climate justice. Countries are not equal in terms of historical contribution to emissions, nor in terms of financial and technological capacity to undertake the transition and adapt to its effects. The climate debate is therefore linked to questions of historical responsibility, financing, technology transfer and the right to development. However, this does not negate the need for all countries to simultaneously face the transformations imposed by global climatic, energy and economic changes.

Energy Transition and International Competition

The energy transition does not occur in a vacuum. Countries compete for technology, investments, markets, strategic metals, new industries, supply chains and skills. Climate policy can therefore become a new field of industrial, commercial and geopolitical competition. A country that succeeds in developing low-carbon industries not only achieves an environmental goal but may also acquire a stronger position in the global economy.

Trade-offs and Difficult Choices

There are not always solutions that achieve all objectives simultaneously. One option may be better in terms of emissions reduction, while another is less costly, quicker to implement or more suitable for energy security. The evaluation of energy and climate policies must therefore balance several elements: emissions

reduction, energy security, cost, competitiveness, development, social justice and implementation capacity. This makes the energy transition a complex political and economic process, not just a technical choice.

Summary of Chapter Five:

Climate has become one of the major factors reshaping the global energy system, but the energy transition does not unfold in an ideal world devoid of interests and competition. Countries simultaneously seek to reduce emissions, secure energy, protect their economies, strengthen their industries and maintain their competitiveness. Commitments to support developing countries also remain an area of negotiation and divergence between promises and their effective implementation. The policymaker must therefore view the energy transition as a transformation that is simultaneously climatic, economic, technological, commercial and geopolitical, and evaluate each option based on its cost, impact, risks and ability to simultaneously achieve multiple objectives.

General Summary

Energy, in the international context, is to be read as a system with interlocking dimensions that cannot be reduced to a single technical or commercial aspect. It is in its essence a fundamental input to the economy, influencing growth, inflation, competitiveness, investment and trade, and reshaping the structure of states for decades.

However, this economic importance also makes it a security issue. The continuity of state and societal functioning depends on the ability to secure reliable and continuous supplies, cope with disruptions through diversification of sources, suppliers and routes, build strategic reserves and develop resilient infrastructure.

This energy security is inseparable from geopolitics. Resources are distributed very unevenly, creating interdependence between producer and consumer countries. This confers strategic importance on certain corridors and infrastructure, and makes energy an instrument of power and influence, sometimes a lever of pressure or negotiation.

One cannot understand the transformations of this system without grasping the role of technology. Technology has modified the equations of extraction, conversion and storage, paved the way for new sources, and made electricity, networks and batteries axes of competition. However, it has also introduced an element of uncertainty. Energy projects are long-term while technology evolves rapidly, potentially making certain options less competitive in the future.

Finally, climate imposes an additional transformation on this system – not only an environmental issue but also an economic, commercial and industrial one. Emissions reduction is now linked to competitiveness. Mechanisms like carbon pricing and border adjustments have emerged. The energy transition has become a space for competition over technology, investments and new markets. At the same time, a persistent gap remains between commitments to support developing countries and their effective implementation.